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(71) Applicant:
SHT Corporation Limited
Osaka-shi, Osaka 530-0038 (JP)

(72) Inventor: **YOSHIMORI, Hitoshi**
Yamatokoriyama-shi, Nara 639-1055 (JP)

(74) Representative:
DIEHL GLAESER HILTL & PARTNER
Patentanwälte
Augustenstrasse 46
80333 München (DE)

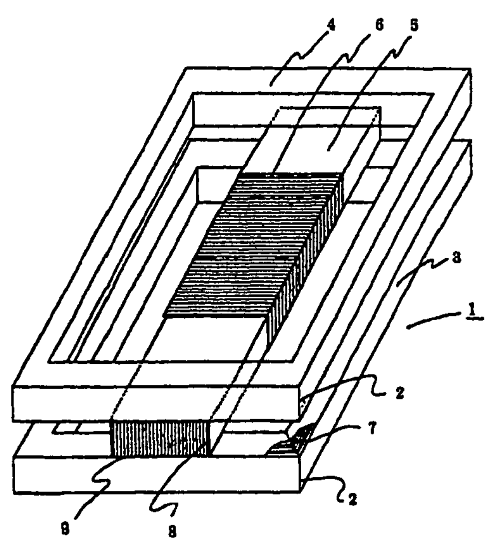
(54) **COIL**

(57) The present invention relates to the structure of coils that can be used for transformers and choke coils. The objective of the present invention is to obtain coils that show little iron loss and a small decrease in inductance due to an increase in electric current.

The structure is a coil comprising a ring-like core (2) made of amorphous or microcrystalline metal on the surface of which at least one bar core (5) whose length is longer than the inside diameter of the aforesaid ring-like core is placed and fixed as shown in Fig. 1, with the aforesaid bar core wound with an electrically conductive material (6) - particularly a coil comprising at least two ring-like cores (2, 2) between the surfaces of which at least one bar core (3) whose length is longer than the inside diameter of the aforesaid ring-like core is inserted and fixed, with the aforesaid bar core wound with an electrically conductive material (5).

Furthermore, the coil of the present invention can be fabricated with great ease compared with the conventional coils with a ring-like core wound with copper wire, such as toroidal coils. The coil of the present invention also shows less iron loss than the conventional coils using cut cores and toroidal cores, and therefore offers the excellent advantages of being able to save energy and showing a small decrease in inductance due to an increase in electric current. Because of this, the coil of the present invention can be utilized for a wide range of applications, such as transformers and choke coils.

Fig. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to coils. More specifically, the present invention relates to those coils for use transformers, choke coils, etc. which comprise a ring-like core and a bar core put on the face thereof and have the structure in which the bar core is wound with an electrically conductive material so that the coils incurs only a little iron loss and are easy to fabricate.

TECHNICAL BACKGROUND

[0002] The coils used or electric and electronic circuits have conventionally been produced by winding an electrically conductive material such as copper wire on a bar-like, pipe-like or ring-like magnetic material. Out of these coils, toroidal coils with copper wire wound on a ring-like magnetic material have been used widely for such applications as high-frequency circuits in recent years. Moreover, those coils using wound cores obtained by winding and stacking each other a thin strip of a magnetic material in the form of a rectangular ring are also used widely. Generally, the work of winding copper wire on a core of a shape having no end, such as toroidal coils, is complicated and cannot be automated easily. Moreover, as the form of cores and wound coils vary greatly, it is difficult to produce toroidal coils efficiently, and there is a limit to the improvement of mass producibility.

[0003] Further, as a method in which copper wire is not wound directly on ring-like or wound cores, another method is used in which copper wire wound on a bobbin is inserted in the cut section of a cut core split into two parts or in each end of a combination of E-shaped and inverted E-shaped cores. This method is also complicated and does not show good workability. Furthermore, since these types of coils are affected by dimensional errors in the bobbin and the coils, it has been difficult to make the size of coils smaller and their density higher.

[0004] The inventor of the present invention studied such structure of coils that would solve these problems and make the manufacture of coils by a simple process possible and would show superior mass producibility, favorable economics and little iron loss. As a result, found that it is possible to manufacture coils that can be produced at high productivity and entails little iron loss, compared with the conventional coils with a wound core wound with copper wire, by winding an electrically conductive material on a bar core, while adopting a structure comprising a ring-like core and a bar core put on the face of the ring-like core. This led to the invention of the present invention.

DESCRIPTION OF INVENTION

[0005] The present invention is concerned with a coil comprising a ring-like core made of amorphous or microcrystalline metal on the surface of which at least one bar core whose length is longer than the inside diameter of the aforesaid ring-like core is placed and fixed, with the aforesaid bar core wound with an electrically conductive material. The most preferable structure is such coil that comprises at least two the aforesaid ring-like cores between the surfaces of which at least one bar core whose length is longer than the inside diameter of the aforesaid ring-like core is inserted and fixed, with the aforesaid bar core wound with an electrically conductive material.

BRIEF DESCRIPTION OF DRAWINGS

[0006]

Fig. 1 is one example of a sketch drawing of the coil of the present invention.
Fig. 2 is a sketch drawing of another example of the coil of the present invention.
Fig. 3 shows magnetic flux density-iron loss curves of the coil of the present invention and a conventional cut core.
Fig. 4 shows superimposed current-inductance curves of the coil of the present invention.

1	Coil
2	Ring-like core
3	Long side of a rectangular ring-like core
4	Short side of a rectangular ring-like core
5	Bar core
6	Copper wire
7	Amorphous metal or microcrystalline metal tape of a ring-like core
8	Magnetic material tape of a bar core
9	Contact area between ring-like core and bar core
10	Gap
A	Magnetic flux density-iron loss curves of the coil of the present invention
B	Magnetic flux density-iron loss curves of the coil of a conventional cut core coil
a	Superimposed current-inductance curves of the cut core of the present invention
b	Superimposed current-inductance curves of a conventional toroidal coil

BEST EMBODIMENTS OF INVENTION

[0007] Following is a description of the present invention given by using drawings. Fig. 1 is one example of a sketch drawing of the coil of the present invention. In Fig. 1, Coil 1 consists of two Ring-like Cores 2, 2 and Bar Core 5 inserted and fixed between the aforesaid one set of ring-like cores, and Bar Core 5 is wound with

Copper Wire 6.

[0008] The ring-like core of the coil is made of amorphous or microcrystalline metal. Metal Tape 7 is wound in the form of a ring and stacked in layers so that a core is formed. In the present invention, amorphous or microcrystalline metal is used for the material of the ring-like core. This makes it possible to obtain coils showing little iron loss.

[0009] Amorphous metal is a metal having no crystalline structure that is obtained by quenching a molten metal. An alloy having such composition that it contains transition metal selected from Fe, Co or Ni, particularly Fe, as its indispensable metal component and B, C, P or Si as its non-metal component is preferable as the material of the wound core of the coil of the present invention because of low iron loss and high saturation magnetic flux density.

[0010] Microcrystalline metal is a soft, microcrystalline magnetic alloy material. It is formed by preparing non-crystalline metal tape by melting and quenching an alloy containing Fe, Si or B as the basic component and a small amount of elements such as Cu, Nb, Ta, Mo and Zr and then by subjecting the tape to heat treatment to crystallize it to form supermicrocrystals of 10 nm order.

[0011] The shape of the ring-like core is generally a rectangular ring shape consisting of Long Side 3 and Short Side 4 as shown in Fig. 1 but may be toroidal or oval. The core is produced by the method in which a long tape of amorphous or microcrystalline metal is wound and stacked in layers on the core.

[0012] In the present invention, the coil is formed by putting a bar core on at least one ring-like core and winding an electrically conductive material on the bar core, but a bar core(s) may be inserted between the faces of not less than two ring-like cores. The adoption of a structure in which one Bar Core 5 is sandwiched between two Ring-like Cores 2 of the same shape as shown in Fig. 1 will enable high inductance to be obtained against a given level of electric current. Because of this, such structure is advantageous in electromagnetic performance and ease of manufacture. On the other hand, with coils, inductance decreases as electric current becomes stronger. However, those coils which are obtained by the bar core is laid in layer on one ring-like core as shown in Fig. 2 have the effect of inductance showing little decreasing tendency and high inductance being maintained at strong electric current. For this reason, such structure may be selected appropriately to meet the requirements of uses.

[0013] The number of the bar core that is put on the ring-like core is normally one, but it may also be not less than two.

[0014] There is no special restriction on the magnetic material that is used for the bar core, and ferrite, Permalloy, etc. as well as amorphous metal, microcrystalline metal and silicon steel which are used for the ring-like core may be used for the aforesaid magnetic material.

[0015] There is no restriction on the position of the bar core relative to the ring-like core as long as the bar core can be put on the face of the ring-like core. However, if the ring-like core is a rectangular ring-like shape, the bar core is preferably positioned in the central part of the ring-like in parallel with one of the ring-like core, particularly its long side. Further, the length of the bar core has to be longer than the inner rim of the ring-like core so that the bar core can be placed on the ring-like core. Normally the length of the bar core is equal to or a little shorter than that of the outer rim of the ring-like core.

[0016] The shape of the bar core may be any indefinite shape but is most preferably a rectangular shape having the same effective cross-sectional area as that of the ring-like core.

[0017] Laminates of thin boards and blocks are used as the form of the bar core, depending on the type of the materials. In the case of materials in the form of thin tape, such as amorphous or microcrystalline metal and silicon steel, a large number of thin boards of the same shape are laminated. Thin boards may be bound to form a cylindrical shape. In the case of making the bar core by laminating thin boards a resin such as epoxy resin may also be impregnated into them to fix them as required. In the case of ferrite, a block-like core is used.

[0018] In the case of using a laminate of Magnetic Tape 8 made of amorphous or microcrystalline metal for the bar core, such bar core is preferably formed by laminating magnetic tape in such manner that the width direction of the tape is at right angles with the face direction of the ring-like core as shown in Fig. 1 (In Fig. 1, the width direction of Tape 8 is upward and downward and crosses the face of the ring-like core that is placed in the horizontal position.) The use of such bar core offers an advantage because there will be no occurrence of eddy current, hence little iron loss since the laminated face of Tape 8 is in parallel with the laminated face of Tape 7 at the side (Long Side 3 in Fig. 1) of the ring-like core that is in a position parallel with the bar core and moreover the face of the magnetic tape forming the ring-like core and that of the magnetic tape forming the bar core do not come into contact.

[0019] The bar core is put and fixed on the face of the ring-like core or inserted and fixed between the faces of two ring-like cores. However, Contact Area 9 between bar core and ring-like core is either fixed in contact with each other or has a gap between them, depending on the uses of the coil. In the case of transformers, the faces of the bar core and the ring-like core are brought into contact in such manner that there is as small a gap between them as possible by grinding the aforesaid faces, for example. However, in the case of choke coils, a proper Gap 10 is provided as shown in Fig. 2. In the case of proving a gap with a coil with the bar core sandwiched between the faces of two ring-like cores, a gap may be provided between the bar core and the two ring-like cores at both ends where the bar core and ring-like core are in contact with each other.

[0020] The bar core is wound with an electrically conductive material so that a coil is formed. Copper wire is most generally used for the electrically conductive material. The number of turns may be selected optionally according to applications. The electrically conductive material may be wound directly in the form of bar core. However, the bar core may also be covered with the electrically conductive material wound on a bobbin or the like. In either case in the present invention, work can be done with great ease because copper wire is wound on the bar core. Further, in the present invention, since the coil is formed by winding copper wire on the bar core, the coil may be used as it is, but the ring-like core may also be wound with copper wire as required.

[0021] The coil of the present invention can be fabricated simply by combining the ring-like wound core and the bar core with an electrically conductive material wound on it. Because of this, coils of any optional size may be produced by the present invention, and the size may be selected as appropriate according to the material used, applications and performance requirements.

[0022] The coil of the present invention not only can be fabricated easily and economically but also has the advantages of little iron loss and lower energy consumption.

[0023] Furthermore, with the coil of the present invention, the bar core is wound with copper wire, which is housed within the frame of the surrounding ring-like core. Hence, the coil becomes compact in structure and makes the reduction of the size of the equipment incorporating the coil possible.

[0024] Because of these characteristics, the coil of the present invention is used for applications such as transformers and choke coils. When the coil is used for choke coils, it is used by adjusting appropriately the gap at the area of contact between the bar core and the ring-like core.

EXAMPLES

Example 1:

[0025] Two rectangular ring-like cores whose rectangular inner frame size is 60 x 55 mm, whose outer frame size is 75 x 70 mm and which is 10 mm in height were prepared by winding and stacking in layer an amorphous metal ribbon (available from Nippon Amorphous Metals Co., Ltd.; composition: Fe, main component, Ni, Si and B) on a rectangular core. In addition, a bar core 80 mm long, 30 mm wide (in the tape stacking direction) and 10 mm high (in the tape width direction) and was prepared by stacking the aforesaid amorphous metal ribbon (10 mm wide), this was wound by 50 turns with copper wire, and this wound bar core was sandwiched between the aforesaid two rectangular ring-like cores with the result that a coil as shown in Fig. 1 was formed.

[0026] The iron loss against magnetic flux density at a frequency of 1 kHz was measured by means of Digital Power Meter 2532, available from Yokogawa Electric Corporation by using the aforesaid coil. Results of the measurement are shown in A of Fig. 3.

Comparative Example 1:

[0027] A cut core was prepared by cutting the central part of a rectangular ring-like core with the rectangular inner frame size of 70 x 20 mm, the outer frame size of 105 x 52 mm and a height of 25 mm which was prepared by winding and stacking in layer the same amorphous metal ribbon that was used in Example 1 on a rectangular core. This cut core was wound by 50 turns with copper wire, with the result that a cut core coil was prepared.

[0028] The iron loss against magnetic flux density was measured in the same manner as described in Example 1 by using the cut core coil. Results of the measurement are shown in B of Fig. 3.

[0029] As can be seen from Fig. 3, the coil of the present invention shows less iron loss and energy loss than the conventional cut core coil obtained by winding copper wire on a cut core.

Example 2:

[0030] A choke coil was formed by putting a bar core on the one rectangular ring-like core used for the coil of Example 1 with a 3-mm gap provided at the areas (two) of contact between the rectangular ring-like core and the bar core as shown in Fig. 2. The relationship of this coil between superimposed current and inductance at a frequency of 1 kHz was measured, and the direct current superimposition properties were evaluated. Results are shown in a of Fig. 4.

Comparative Example 2:

[0031] A circular ring-like core 60 mm in outside diameter, 35 mm in inside diameter and 25 mm in width which has a 3-mm gap and about the same core weight as that of the coil of Example 1 was prepared. A toroidal coil was prepared by making 47 turns of winding copper on the aforesaid circular ring-like core, and the relationship of this coil between superimposed current and inductance at a frequency of 1 kHz was measured, and the direct current superimposition properties were evaluated. Results are shown in b of Fig. 4.

[0032] As can be seen from Fig. 4, the coil of the present invention shows a less decrease in inductance due to an increase in electric current than the conventional toroidal coil.

POSSIBILITY OF INDUSTRIAL APPLICATION

[0033] In the present invention, coils can be obtained simply by inserting a bar core with an electrically conductive material wound on it into a ring-like wound core,

and thus the present invention provides a very easy coil fabrication method compared with the conventional coils obtained by winding copper wire on a ring-like core.

[0034] Furthermore, the coil of the present invention shows less iron loss than the coils using conventional cut cores, and therefore offers the excellent advantages of being able to save energy and showing a small decrease in inductance due to an increase in electric current. Because of this, the coil of the present invention can be utilized for a wide range of applications, such as transformers and choke coils.

Claims

1. A coil comprising ring-like core(s) made of amorphous or microcrystalline metal on the surface of which at least one bar core whose length is longer than the inside diameter of the aforesaid ring-like core is placed and fixed, with the aforesaid bar core wound with an electrically conductive material.

2. A coil comprising at least two ring-like cores made of amorphous or microcrystalline metal between the surfaces of which at least one bar core whose length is longer than the inside diameter of the aforesaid ring-like core is inserted and fixed, with the aforesaid bar core wound with an electrically conductive material.

3. A core as defined in Claim 1 or 2 above, wherein the bar core is consisting of magnetic tapes stacked in layers in such manner that the width direction of the tapes is at right angles with the face direction of the ring-like core.

4. A coil as defined in any of Claims 1 through 3 above, wherein the ring-like core is a rectangular ring-like core and the bar core whose length is longer than the inner rim of the long side of the rectangular ring-like core is put approximately in the middle of the two long sides of the rectangular ring-like core in parallel with these long sides.

5. A coil as defined in any of Claims 1 through 4, wherein a gap is provided between the face of the ring-like core and the bar core.

6. A transformer using the coil as defined in any of Claims 1 through 5.

7. A choke coil using the coil as defined in any of Claims 1 through 5.

Fig. 1

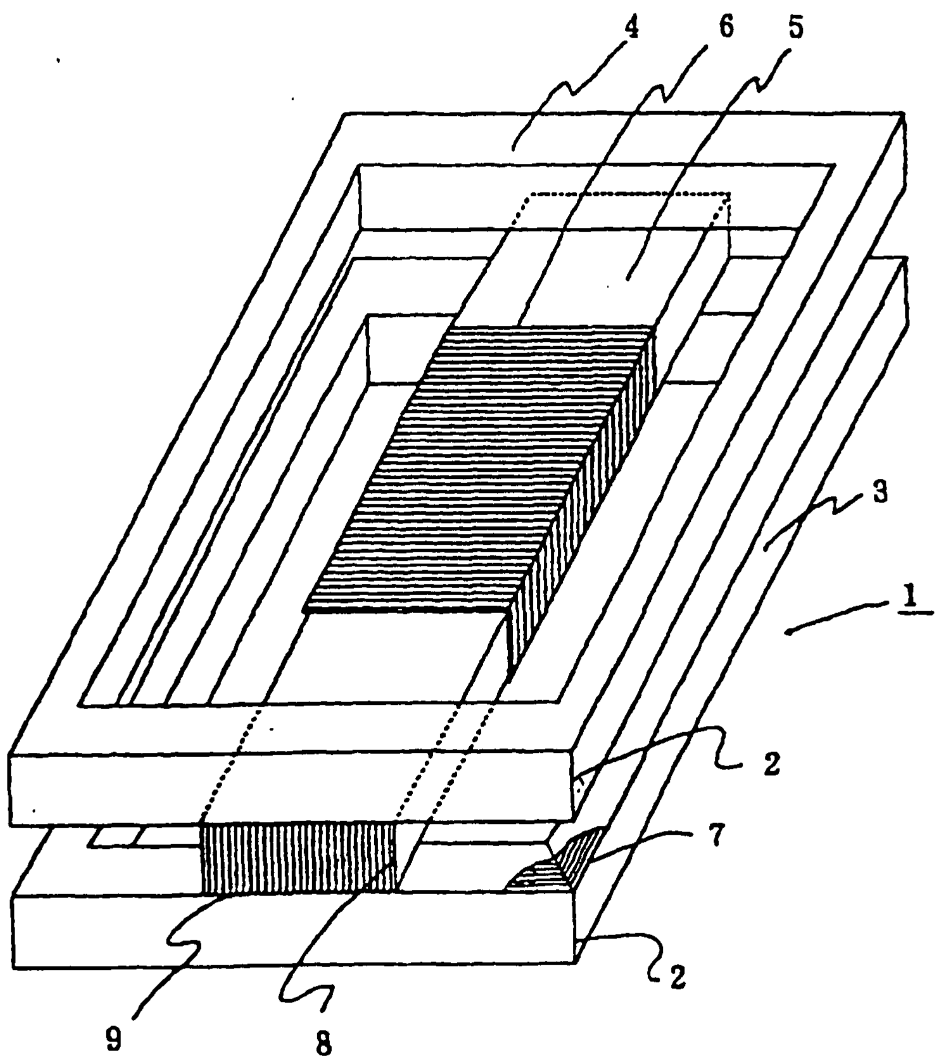


Fig. 2

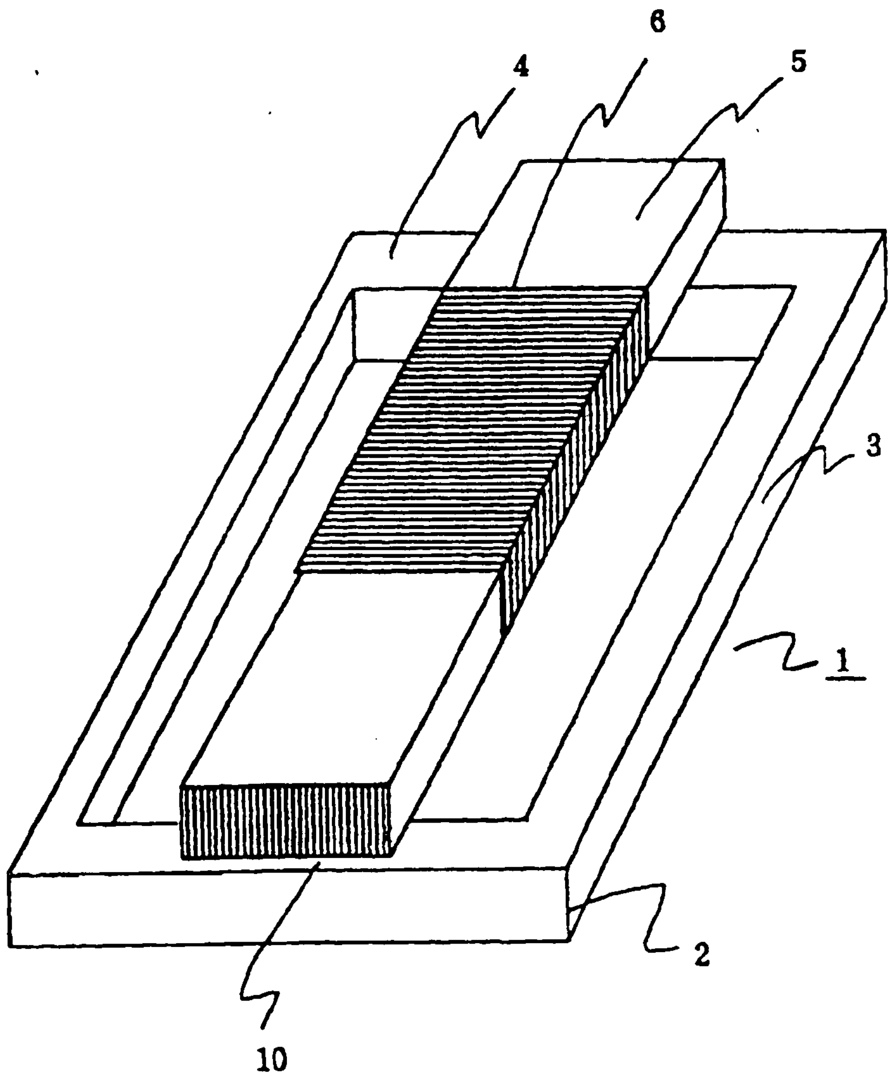


Fig. 3

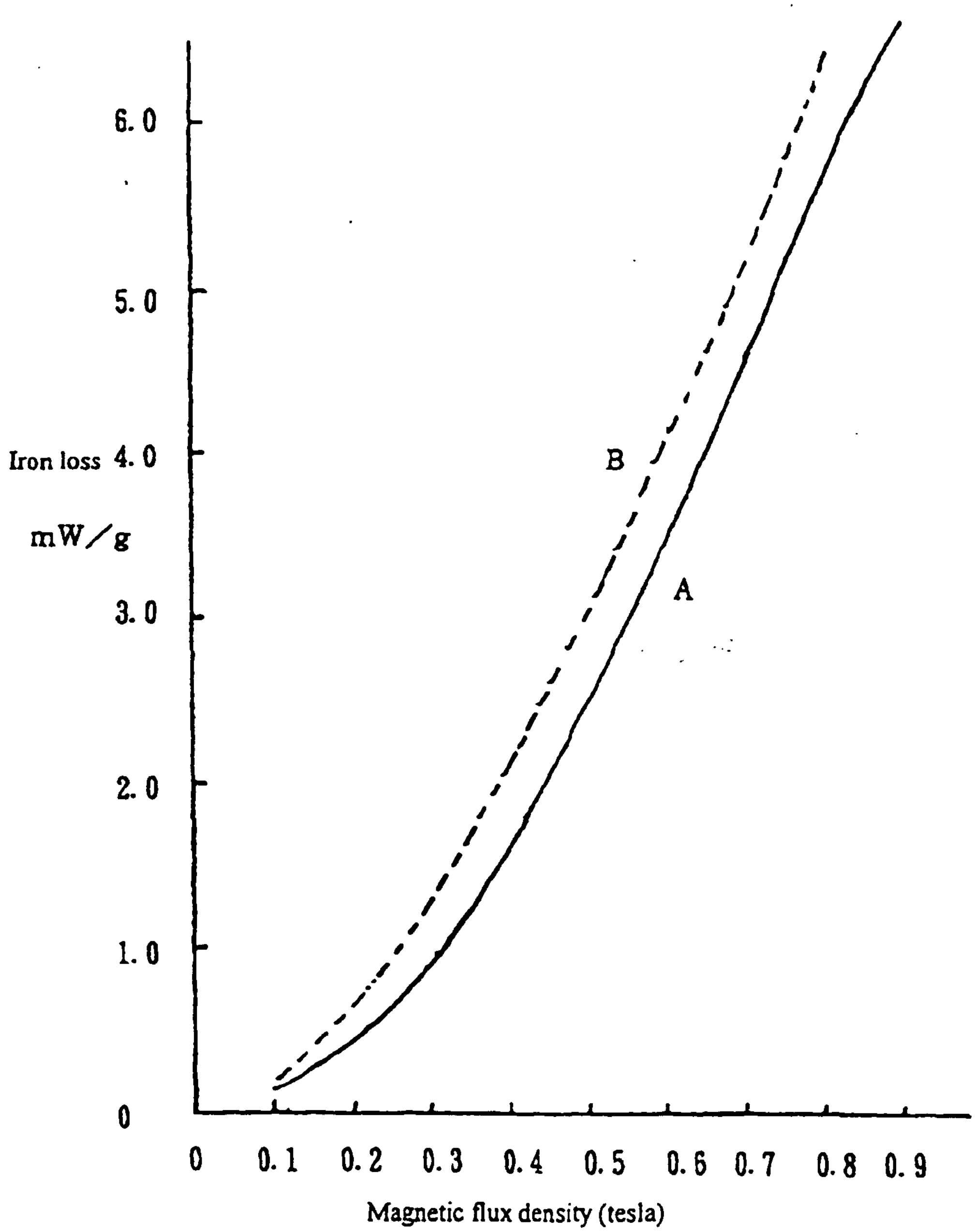
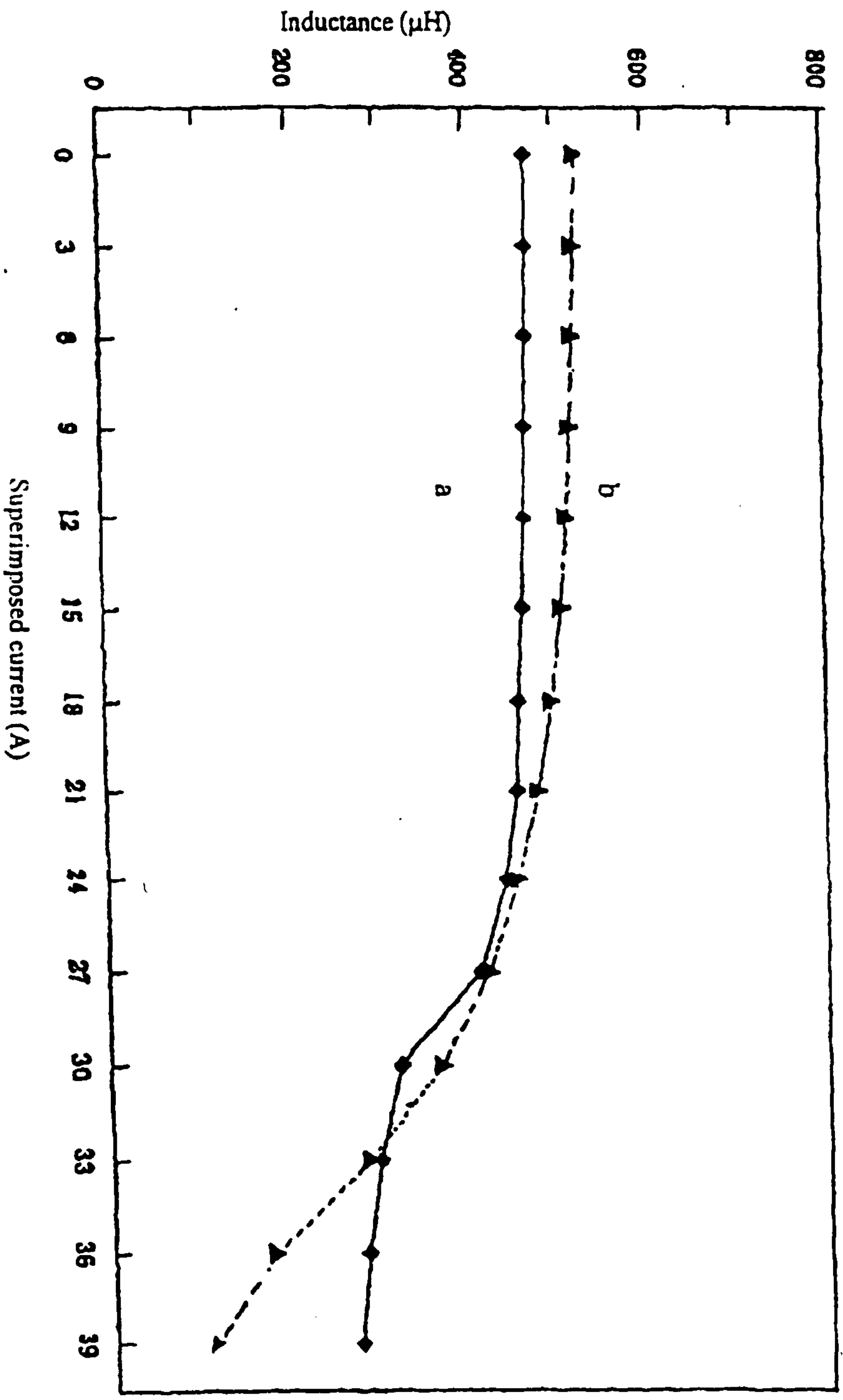

6.0
5.0
Iron loss 4.0
mW/g
3.0
2.0
1.0
0
B
A
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Magnetic flux density (tesla)

Fig. 4


Inductance (μH)
0
200
400
600
800
0
3
6
9
12
15
18
21
24
27
30
33
36
39
a
b
Superimposed current (A)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/02867

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] H01F27/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] H01F27/24-27/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-1998
Kokai Jitsuyo Shinan Koho	1971-1998	Jitsuyo Shinan Toroku Koho	1996-1998

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 59-26209, U (Matsushita Electric Industrial Co., Ltd.), 18 February, 1984 (18. 02. 84) (Family: none)	1-7
Y	JP, 58-140625, U (Toa Tsushin Kogyo K.K.), 21 September, 1983 (21. 09. 83) (Family: none)	1-7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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